Introduction

Childhood conduct problems comprise one of the disruptive behavior disorders in children with some of its central features being aggressiveness, oppositionality and antisocial behavior (American Psychiatric Association, 2013). According to official classification systems of mental health, severe levels of conduct problems in childhood are classified as Oppositional Defiant Disorder or Conduct Disorder (American Psychiatric Association, 2013; World Health Organization, 1992). The pooled global prevalence of a conduct disorder diagnosis in 5–19 year old children is 1.5% for girls and 3.6% for boys (Erskine et al., 2013). The prevalence of symptoms of conduct problems reported in the school population can be as high as 26% (Hyland, Ni Mhaille, Lodge, & McGilloway, 2013). Conduct problems comprise one of the most common reasons of referral to child psychological and psychiatric services (Scott, 2015) and is the most commonly identified mental health problem in the school population (Green, McGinnity, Meltzer, Ford, & Goodman, 2005). Prognosis for early onset conduct problems is poor. Severe levels of conduct problems in the primary school years put children at high risk for a wide range of psychosocial problems in early adulthood including crime, substance abuse, mental health problems, poor partner relationships, unemployment and welfare dependence (Fergusson, Horwood, & Ridder, 2005; Kretschmer et al., 2014).

Reading comprises a core curriculum subject (Vitikka, Krokfors, & Hurmerinta, 2012) and in the early primary school years academic success is largely defined by good reading skills. Children with both clinically and non-clinically significant conduct problems are at great risk of poor reading skills. Data from a large UK population-based study reveal that 14% of 5 to 15 year olds with specific literacy difficulties have a conduct disorder (Carroll, Maughan, Goodman, & Meltzer, 2005).

Recent data drawn from another UK representative population-based sample show that 7-year-old children with reading difficulties are more likely to exhibit high rates of conduct problems than children without (Russell, Ryder, Norwich, & Ford, 2015). The combination of conduct and reading problems in children can trigger a chain of cumulative disadvantage. Reading difficulties can lead to generalized academic failure as children who are poor readers become less capable of making the most of the reading experience that promotes learning and the acquisition of higher cognitive skills (Stanovich, 2000). Academic failure combined with conduct problems can lead to antisocial behavior in adulthood. Longitudinal data from the Christchurch Health and Development Study, New Zealand demonstrate that crime rate is 38% to 78% higher amongst young adults who have conduct problems in childhood and leave school without any qualifications than amongst those who leave school with qualifications (Jakobsen, Fergusson, & Horwood, 2012).

Good interventions rely on accurately identifying and addressing the actual presenting problem that is to be treated (Weisz, Chorpita, Palinkas, & et al., 2012). In this process, understanding the heterogeneity often encountered within a disorder is of paramount importance (Kennedy, 2015). To date, limited research has been conducted to examine the heterogeneity encountered amongst children with conduct problems as a result of exhibiting additional difficulties in reading. To a certain extent, this is because coexisting problems of conduct and reading in children have traditionally been understood as the product of co-occuring difficulties of inattention and hyperactivity (Carroll et al., 2005; Frick et al., 1991; Maughan, Pickles, Hagell, Rutter, & Yule, 1996). However, more recent studies failed to find a specific relationship between poor reading skills and inattention and hyperactivity in children with conduct problems and have actually revealed new factors that potentially explain

coexisitng conduct and reding problems in children. For example, data from the Environmental Risk (E-Risk) Longitudinal Twin Study, a nationally representative 1994 – 1995 birth cohort of 5- and 7-year-olds in the UK, demonstrate that the association between antisocial behavior and poor reading is significant even after symptoms of inattention and hyperactivity are statistically controlled and partially mediated by home learning environment (Trzesniewski, Moffitt, Caspi, Taylor, & Maughan, 2006). Furthermore, data from a Greek school population show that young children with conduct problems, but intact reading skills, have significantly high levels of inattention and hyperactivity too, and that the parents of children with coexisting conduct and reading problems spend fewer years in education (Kallitsoglou, 2014). These findings do not provide a clear pricture about the actual deficits exhibited by children with conduct and reading problems and whether they experience a different set of difficulties compared to children with conduct problems but normative reading skills. Further research to identify those difficulties will advance our understanding of the heterogeneity encountered in children with conduct problems and contribute to the ongoing research on effective intervention development for this population.

In recent years, a lot of emphasis in children's academic attainment has been placed by research in executive functions. These are top-down high order cognitive functions that operate as a control system to facilitate goal directed behaviors (Best & Miller, 2010; Jurado & Rosselli, 2007). Response inhibition, planning and working memory skills are amongst the most representative executive functions (Best & Miller, 2010; Pennington & Ozonoff, 1996). Good executive function skills are considered to be the cornerstone of academic success (Center on the Developing Child at Harvard University, 2011). They are highly predictive of academic

attainment (Pearson et al., 2016) and provide the platform to develop domain-specific skills like reading (Best, Miller, & Naglieri, 2011).

Executive function deficits are generally found in populations with conduct problems, independent of additional difficulties (Ogilvie, Stewart, Chan, & Shum, 2011). There is consistent evidence that young children with conduct problems exhibit poor performance in executive function tasks that involve motivational processes and incentives, irrespectively of associated inattention and hyperactivity (Matthys, Vanderschuren, & Schutter, 2013; Rubia, 2011; Schoemaker et al., 2012). Impairment in executive function tasks heavily laden with cognitive processing is also found in children with conduct problems. Difficulties in response inhibition are associated with aggressive behavior and conduct disorder in primary school (6-12 years) and preschool (4 years) children (Oosterlaan, Logan, & Sergeant, 1998; Raaijmakers et al., 2008), independent of inattention and hyperactivity.

Executive function deficits are also found to be independently correlated to reading difficulties. A meta-analysis of 48 studies reports an effect size of half a standard deviation between school age children with and without reading difficulties (Booth, Boyle, & Kelly, 2010). Word and text reading difficulties are associated to poor performance in response inhibition (de Jong et al., 2009; Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2005), verbal working memory (Marzocchi et al., 2008; Rucklidge & Tannock, 2002) and fluency and set shifting (Marzocchi et al., 2008) tasks, independent of symptoms of inattention and hyperactivity and intelligence. Reading comprehension difficulties and poor planning skills consistently co-occur in children after symptoms of inattention and hyperactivity and language difficulties are statistically controlled (Locascio, Mahone, Eason, & Cutting, 2010).

Reading difficulties and executive function deficits appear to cluster together in youths with severe levels of conduct problems. Earlier data from the Dunedin Multidisciplinary Health and Development Study, New Zealand demonstrate that 13-year-old youths with antisocial behavior and attention deficit have significantly weaker reading and executive function skills as measured by a battery of neuropsychological tests, including executive function tests, than those without attention deficit (Moffitt & Silva, 1988). More recent findings from a sample of Chinese boys with a mean age of 14 years old, residing in institutional care for juvenile offenders, show that those with reading difficulties and attention deficit and hyperactivity disorder exhibit difficulties in more components of executive function than those with attention deficit and hyperactivity only (Poon & Ho, 2014). These findings suggest that youths with antisocial behavior and coexisting reading difficulties are more likely to experience complications in executive functioning than youths with antisocial behavior but good reading attainment. However, these results may not be applicable to very young children with less severe antisocial behavior. Additionally, they do not reveal whether the executive function deficits in youths with antisocial behavior are explained by either coexisting inattention and hyperactivity or reading difficulties. It is plausible that their executive function deficits are the result of inattention and hyperactivity as the incidence of co-occurrence of executive function impairment and attention deficit and hyperactivity is very high. On the other hand, the literature shows that reading problems are also strongly associated to executive function weaknesses. Furthermore, the Chinese study by Poon and Ho (2014) shows that the youths in the combined condition experience more difficulties, independently of coexisting inattention and hyperactivity. Therefore, it is possible that

reading difficulties comprise a candidate explanatory factor of executive function difficulties in children with conduct and reading problems.

To summarise, research findings suggest that adolescents with antisocial behavior and reading difficulties are more likely to have additional difficulties in executive functioning but it is not known whether this is true for younger children. These findings were replicated in young children with milder symptoms of antisocial behavior; it was examined whether there were any differences in executive function task performance between young children with conduct problems and poor reading skills, children with conduct problems but typical reading skills, children with poor reading skills but no conduct problems and children with neither conduct problems nor poor reading skills. The literature shows that reading problems are also independently associated with weaknesses in executive function and that poor performance in reading and executive function tests is positively correlated in young people with antisocial behavior. These findings propose that having additional reading difficulties may compromise the executive functioning of children with conduct problems but this premise has not been examined to date. To address this research gap the effect of the two conditions on children's performance on executive function tasks was examined. A strong association exists between executive dysfunction and attention deficit and hyperactivity (Schoemaker et al., 2012; Willcutt et al., 2005) and children with conduct problems are known to score low in intelligence tests (Hill, 2002; Moffitt, 1990; Ogilvie et al., 2011). As a result, it was examined whether differences in executive function task performance were independent from coexisting symptoms of inattention and hyperactivity and intellectual ability.

Method

Participant recruitment

Children attending 2nd-grade in state primary schools in the greater area of Western Thessaloniki, Greece were recruited to the study. First, eligible schools were identified. School eligibility was based on whether teachers thought they had at least one child with conduct problems in the classroom. The Conduct Problems scale of the Greek version of the Conners' Teacher Rating Scale-28 (CTRS-28) (Roussos et al., 1999) was presented to teachers to help them understand the kind of behavior the study was targeting. Teachers identified 65 children with potential conduct problems in 22 (n=684) out of 32 schools initially agreed to participate in the study. Positive informed consent was collected for 286 children (41%) out of 684 children in the eligible schools.

Secondly, eligible children were allocated to four groups: conduct problems and poor reading (CP-PR); conduct problems only (CP); poor reading only (PR); comparison children (COM). Eligible children had to meet the criteria for either conduct and/or poor reading skills, have a positive parental consent, no global developmental delay in line with school records and speak Greek. In addition, children in the COM group had to be free of symptoms of inattention and hyperactivity. Teachers were asked to fill out the CTRS-28 (Roussos et al., 1999) for any child in the classroom that exhibited symptoms of conduct problems. To meet the criteria for conduct problems a child had to receive a total score of ≥ 8 on the CTRS-28. This score corresponds to a level of behavior problems reached by the top 10% of children in the Greek school population (Roussos et al., 1999). Of the sixty five children initially suggested as potentially having conduct problems, 54 met the criteria

for conduct problems and were eligible to participate in the study. To determine whether children had poor reading skills a screening test for the detection of reading ability (Tafa, 1995) was administered to consented children in the eligible schools. To meet the criteria for poor reading skills a child had to achieve a standard score of ≤ 90 on the reading test. This score corresponds to a level of reading difficulty experienced by the top 25% of the Greek school population on the screening test for reading ability (Tafa, 1995). The 25% percentile is a common choice of cut-off point for the identification of low achieving readers (Condor, Anderson, & Saling, 1995; Fletcher et al., 1998; Rucklidge & Tannock, 2002). Twenty eight out of 54 children with conduct problems scored ≤ 90 on the reading test and formed the CP-PR group and 26 scored > 90 and formed the CP group. The children who scored below the cut-off point in the reading test, but had not been initially identified by their teachers as having conduct problems, comprised the recruitment pool for the PR group. Of these children, those who did not meet the criteria for conduct problems on the CTRS-28 (score < 8) were recruited to the PR group. To obtain similar numbers of children across the four groups allocation to the PR group stopped when a number of children similar to that of the other groups was achieved. As a result, 36 children were recruited to the PR group. Thirty-one children were recruited to the COM group and matched with children with conduct problems to balance the gender ratio across the groups as follows: for every other child in the classroom with conduct problems the next child from the class register that was of the same gender and did not have reading problems was identified and the CTRS-28 was completed. COM children scored <8 on the Conduct Problems scale, < 11 on the Inattention scale and < 9 on the Hyperactivity scale of the CTRS-28, and > 90 on the reading test. A total of one hundred and twenty one children were recruited of which 119 were white Greek and

two of other white ethnic background. Ethical approval was granted by the Ethics Committee of the Pedagogical Institute of Greece. Permission to carry out the study was also obtained by the Local Educational Authority of Western Thessaloniki.

Measures

Conduct problems and poor reading skills

Conners' Teacher Rating Scale-28 (CTRS-28) - Greek version (Roussos et al., 1999): The Conduct Problems (8 items), Inattentive-Passive (8 items), and Hyperactive (7 items) subscales were used to identify eligible children. Each item is rated on a 4-point scale: not at all (0), just a little (1), pretty much (2), very much (3). The psychometric properties of the Greek version of the CTRS-28 have been tested in a large community sample (Roussos et al., 1999). It can successfully discriminate between clinical and non-clinical populations and confirmatory factor analysis showed that the American factors were similar to the Greek. Furthermore, it correlates highly with the Greek version of the Teacher Report Form of the Child Behavior Checklist, a long established measure of childhood behavior problems. In the present sample, Cronbach's alpha was 0.84 for the Conduct Problems scale, 0.89 for the Inattentive-Passive scale and 0.93 for the Hyperactivity scale.

Screening test for reading ability (Tafa, 1995): This is a standardized sentence-completion screen measure of reading ability in Greek developed for 6- to 10-year-old children. It comprises of 42 sentences that become progressively more difficult. The child is required to select the correct word from a total of four words to complete the missing sentence. Test administration is 40 min. It has good reliability (Guttmann

split-half = 0.93; Chronbach's alpha= 0.94) (Tafa, 1995) and correlates highly with teacher ratings of children's reading ability (Triga, 2004).

Intellectual ability

Wechsler Intelligence Scale for Children, 3rd edition – Greek version (WISC-III, Greek): Vocabulary (Georgas, 1997): The Vocabulary subtest of the Greek version of the WISC-III for 6- to 16-year-old children was used to produce an estimate of intelligence. The Vocabulary subtest is the best single indicator of general intelligence (Groth-Marnat, 2003) and is commonly used as a proxy to measure general intelligence (Albert & Steinberg, 2011; Jensen, 2001; Poon & Ho, 2014). It comprises a list of 30 words. The sum of correctly defined words is the child's total raw score. Chronbach's alpha for 7 year olds is 0.68 (Georgas, 1997).

Executive function

Wechsler Intelligence Scale for Children, 3rd edition – Greek version (WISC-III, Greek): Backward Digit Span (Georgas, 1997): The Backward Digit Span subtest of the Greek WISC-III was used to assess verbal working memory. Children are asked to recall 14 sequences of backward digits starting with two digits and increasing to eight. The sum of correctly recalled digits is the child's total raw score. The user manual does not report reliability coefficients for the Backward Digit Span subtest.

Conners' Continuous Performance Test – 2nd edition (CPT-II) (Conners & Staff MHS., 2000): The Conners' CPT-II is a well-established neuropsychological task (for detailed description and psychometric properties see Conners, Epstein, Angold, & Klaric, 2003; Conners & Staff MHS., 2000 ; Homack & Riccio, 2006). The child is asked to respond as quickly as possible to the computer by pressing the spacebar for every letter presented on the screen except for the letter 'X'. Time intervals between letter presentations (inter-stimulus intervals: ISIs) are 1, 2, and 4 seconds and are randomly interspersed, with a display time of 250 ms. There are six blocks, with three sub-blocks, each containing 20 letter presentations for each ISI. Commission errors (the failure to stop a response to a non-target 'X') comprise the main index of inhibitory control (Soreni, Crosbie, Ickowicz, & Schachar, 2009) and were used to assess motor inhibition to a prepotent response. Scores above 55 indicate poor performance, scores between 45-54 indicate average performance and scores below 44 indicate very good performance. Split half reliability for all of the CPT performance measures are reported between 0.66 and 0.95 (Conners et al., 2003). Test-retest reliabilities for a 3-month interval are reported between 0.55 and 0.84 (Conners et al., 2003).

Tower of London (TOL) (P. Anderson, Anderson, & Lajoie, 1996): TOL tasks measure the planning aspect of executive function (Albert & Steinberg, 2011; Berg & Byrd, 2002; Pennington & Ozonoff, 1996; Unterrainer et al., 2004). The individual is required to solve a pre-specified number of visuospatial problems in a timely and efficient manner. An adapted version for children of the original TOL task (Shallice, 1982) was used (P. Anderson et al., 1996). The apparatus includes three different coloured wooden balls (green, blue, red) and three wooden sticks of different length

positioned at equal intervals on a wooden pegboard. The first stick can carry three balls, the second stick can carry two balls, and finally, the third one can carry only one ball. The task includes 1 practice and 12 planning problems. For each problem the child is presented with a standard configuration of the three balls. The child is expected to achieve a new configuration depicted on a plastic stimulus card by re-arranging the balls in a fixed number of minimum moves ranging from 2, 3, 4 and 5, each indicating a different level of difficulty, and by adhering to the following rules: a) move only one ball at a time, b) hold no more than one ball, c) do not place balls on the table, d) only use one hand, e) do not place more balls than the required number onto the sticks. A maximum problem solution time of 60 seconds is used, but the child is unaware of time limits. The measure has been validated for its content and discriminant validity by previous research. Performance on the adapted version significantly correlates with performance on other recognized measures of executive function in school children between 7- to 13- year old children (P. Anderson et al., 1996). Additionally, children with neurological deficits make significantly more mistakes to plan the task than control children (Jacobs & Anderson, 2002). Reliability coefficients for this and similar non-computerized versions are not reported in the literature (P. Anderson et al., 1996; V. A. Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Berg & Byrd, 2002; Jacobs & Anderson, 2002; Krikorian, Bartok, & Gay, 1994; Rainville, Lepage, Gauthier, Kergoat, & Belleville, 2012). The Cronbach alpha internal reliability coefficient for the original version is 0.25 (Krikorian et al., 1994). Despite the reported low internal consistency the current version has advantages as it is has documented content and discriminant validity and has been adapted for use with young children.

The scores typically used to assess performance on the TOL can be broadly classified in two three categories: accuracy, speed and efficiency of planning (Berg & Byrd, 2002; Jacobs & Anderson, 2002). Accuracy is often conceptualized as the number of correctly solved items. Speed of planning is often reflected in the average time taken to plan and execute a problem. Efficiency is reflected in the strategies used to solve the problem, for instance, the number of times a problem is attempted before it is solved and the number of times a rule is broken. Often children manage to solve the problems but make more mistakes in the process. These scores are very effective in capturing these subtle but important differences in performance. Also, they distinguish typical children from children with frontal lobe lesions (Berg & Byrd, 2002; Jacobs & Anderson, 2002). The following commonly used scores were recorded: a) total number of perfect solutions (accuracy): the number of problems solved in the correct number of moves and within the maximum solution time of 60 seconds (range 1-12); b) solution planning time (speed): the length of time in seconds between the problem presentation and the completion of the first move; c) total number of failed attempts (efficiency): the number of times a problem is attempted before a solution is produced; d) total number of rule violations (efficiency): the number of rules violated during the execution of each problem (range 1-5).

Procedure

Teacher questionnaires were administered and collected by the author. Children were assessed on the reading test in groups and individually on the executive function tasks by the author in a quiet room within the school premises. The vocabulary and executive function tests were administered as part of a larger battery of tests. Test administration was completed in three sessions lasting a maximum of 30 minutes each. To add variety of stimuli and excitement to the test administration procedure

verbal tests were interchanged with tests that were more perceptual in nature. Moreover, difficult tasks were followed by less complex tests. All tasks were preceded by practice trials. Children were rewarded with stickers upon completion of each individual assessment session.

Data preparation and analytical plan

The Statistical Package for the Social Sciences (SPSS), version 22 was used to carry out the analysis. There were only two cases with missing data on the TOL solution planning time score, one on the TOL problem solution time and one on the CPT-II Commission errors score so no action to treat missing values was taken. Two cases with unusually extreme scores that could not be attributed to any data entry errors were excluded from the analysis. As a result, from the n=121 children that were originally recruited to the study the data from n=119 were used in the analysis. The analysis had two aims: a) examine whether executive function task performance in the combined condition (CP-PR) is different from the performance in the single conditions. One-way analysis of variance (ANOVA) with Tukey Honest Significant Different test was used to examine between-group differences; b) examine the effect of the single conditions and of their interaction on executive function task performance. A two-way (2x2) between-groups ANOVA was used with conduct problems as one factor with two levels (CP vs no CP) and reading problems as a second factor with two levels (PR vs no PR). Analysis of covariance (ANCOVA) with Bonferroni post hoc tests was used to statistically control for the effects of confounding variables. An alpha level equal to 0.05 was employed for all analyses. According to the American Psychological Association publication guidelines p values

should be reported exactly except for when p=.000 in SPSS in which case the p value should be reported as $p < 0.001$ (American Psychological Association, 2010). The other values were rounded to two decimal places.

Confounding variables

To account for the possibility that potential group differences result from intellectual differences or symptoms of inattention and hyperactivity, the effects of vocabulary and teacher ratings of inattention and hyperactivity were statistically controlled. Because working memory is strongly correlated with TOL task performance (Albert & Steinberg, 2011; Rainville et al., 2012) significant group differences in the TOL task were further analysed by statistically controlling for the effects of children's scores on the backward digit span test.

Results

Group characteristics

The groups did not differ significantly in age and gender (Table 1) but the PR group had almost equal number of girls and boys. This was an unexpected finding as boys normally outnumber girls in reading difficulties (Rutter et al., 2004). As a result, all the analyses were also statistically controlled for gender. Rates of conduct problems and reading performance were comparable between the CP-PR and the single problem groups (Table 1) even after controlling for gender and symptoms of inattention and hyperactivity ($F(3,112)=58.16$, $p < 0.001$, $\eta_p^2=0.61$). This finding suggests that

coexisting conduct problems and poor reading were not related to the severity of either condition. Children with conduct problems in either group were significantly more hyperactive than children without conduct problems even after controlling for gender influences ($F(3,114)=32.78$, $p < 0.001$, $\eta_p^2=0.46$) and had, on average, a level of hyperactivity equal to that reached by the top 10% of the population (9≤) (Table 1). Children in the CP-PR group were significantly more inattentive than children in the other groups with an average level of inattention above the level reached by the top 10% of the population (≥11). Children in the CP and PR groups had similar levels of inattention but they were significantly more inattentive than children in the COM group (Table 1). The significance and directions of the results did not change after controlling for the influence of gender ($F(3,114)=25.34$, $p < 0.001$, $\eta_p^2=0.40$). The COM group had the highest vocabulary score than any of the other three groups, which did not differ significantly from each other. The difference remained significant after controlling for gender and symptoms of inattention and hyperactivity ($F(3,112)=5.46$, $p=0.002$, $\eta_p^2=0.13$).

Group comparisons in verbal working memory

A statistically significant between-group difference was found in the WISC-III Backward digit span subtest. The post hoc test revealed that the CP-PR group scored significantly lower than the CP and COM groups (Table 2) and the PR group significantly lower than the COM group. Once the influences of gender and vocabulary were statistically controlled the CP-PR group did not differ from the CP group ($F(3,113)=5.69$, $p < 0.001$, $\eta_p^2=0.13$). The analysis was run again to control for the effects of symptoms of inattention and hyperactivity; the between-group

difference was still significant (F(3, 111)=4.17, p=0.008, η_p^2=0.10). The post hoc test showed that after the effects of inattention and hyperactivity were controlled only the difference between the PR and COM group was statistically significant. The main effect of the PR condition was statistically significant even after controlling for gender and vocabulary influences (Table 3). After controlling for symptoms of inattention and hyperactivity the PR effect was still significant explaining 10% of the variance in children's backward digit span scores (Table 3).

Group comparisons in motor response inhibition

All groups scored within the average range of scores on the CPT-II Commission errors measure (M score = 45-55). Children in the CP group scored closer (M=52) to the top of the range than the children in the other groups and children in the PR group noted the best performance (M=46). These findings show a tendency for children in the CP group to make more commission errors, which suggests a poorer performance associated with symptoms of conduct problems. Nonetheless, the trend did not reach statistical significance as it was shown by the analysis of variance (Table 2). Control for gender and vocabulary effects reduced the trend a lot more (F(3,112)=2.14, p=0.099, η_p^2 = 0.05). The two-way analysis also showed a tendency for children with CP to make more commission errors but it was only marginally significant; the CP group effect was significant at p=0.048. Statistical control of gender, vocabulary and verbal working memory influences reduced only slightly its significance (Table 3), but further control of symptoms of inattention and hyperactivity reduced it considerably to p=0.368.

Group comparisons in planning

TOL Solution planning

Each group spent approximately 5 seconds to plan a solution (Table 2). No significant between-group differences (Table 2) and no group or interaction effects were identified (Table 3).

TOL Rule violations

On average, children in the CP-PR group violated one more rule than the other groups (Table 2). The between-group difference was statistically significant (Table 2) and the post hoc test showed that children with CP-PR experience greater difficulty in monitoring their mistakes than CP and COM children. However, the results were not statistically significant when the effects of gender and vocabulary were controlled ($F(3,113)=2.12$, $p=0.101$, $\eta_p^2=0.05$). The two-way analysis revealed a significant PR effect, which was only marginally significant after controlling for the effects of gender and vocabulary (Table 3). After controlling for verbal working memory influences the PR group effect was not significant anymore.

TOL Failed attempts

The COM and PR groups made fewer attempts before they reached a solution than the CP and the CP-PR groups (Table 2). A significant between-group difference was found (Table 2) and post hoc tests showed that the PR group made a significantly lower number of failed attempts compared to the CP-PR group. The difference remained significant after controlling for influences of gender and vocabulary

(F(3,113)=3.60, p=0.016, η_p^2=0.09) and verbal working memory (F(3,112)=3.46, p=0.019, η_p^2=0.09). However, when the effect of inattention and hyperactivity was controlled the differences between the groups were not significant (F(3,110)=1.44, p=0.236, η_p^2=0.04). The CP group effect was statistically significant even after removing the effects of gender, vocabulary and verbal working memory, but after controlling for associated inattention and hyperactivity it was not significant anymore.

TOL Perfect solutions

The groups did not differ significantly from each other in the number of correct solutions achieved; on average, each group solved correctly 9 out of 12 problems (Table 2). A marginally non-significant CP group effect was found (Table 3). Further examination of the influence of gender, vocabulary and verbal working memory on the CP group effect did no alter the trend for poorer performance by children with conduct problems (Table 3). When inattention and hyperactivity ratings were statistically controlled a clear non-significant CP group effect was revealed (Table 3).

Discussion

Limited research has been carried out to examine whether children with conduct problems present a different set of weaknesses depending on whether they coexist with reading difficulties. A sample of young children with teacher-rated conduct problems drawn from a school population was used to examine whether: a) children with CP-PR are more likely than children with CP, PR and COM children to exhibit

poor executive function task performance; b) poor executive function task performance in children with CP-PR is explained by either coexisting poor reading skills or the combination of CP and PR; c) symptoms of inattention and hyperactivity and weak verbal skills account for poor executive function task performance in children with CP-PR. Three aspects of executive functioning were examined: verbal working memory, response inhibition and planning.

The results demonstrated that children with CP-PR are more likely to exhibit difficulties in working memory than children with CP. Children and adolescents with conduct problems are consistently found to exhibit weak verbal abilities (Hill, 2002; Moffitt, 1990; Närhi, Lehto-Salo, Ahonen, & Marttunen, 2010; Ogilvie et al., 2011). The findings extend previous research by showing that actually there can be variation in the verbal working memory skills of children with conduct problems depending on whether they exhibit additional reading difficulties. Once the effects of gender and intellectual ability were statistically controlled the CP-PR group did not differ from the CP group in verbal working memory. These findings suggest that variation in verbal working memory skills in children with CP-PR is partially explained by differences in intellectual abilities. The findings also suggest a specific relationship between poor reading and verbal working memory. The PR group had a significantly lower performance in verbal working memory than children in the COM group and the PR condition explained 10% of the variance in verbal working memory scores even after controlling for gender, vocabulary and symptoms of inattention and hyperactivity. This is a plausible explanation as verbal working memory is one of the core deficits in children with reading difficulties (Pham & Hasson, 2014).

Overall, the findings demonstrated that response inhibition is not strongly associated to either conduct or reading problems and that coexisting reading

difficulties do not increase the risk for response inhibition impairment in children with conduct problems. The analysis revealed a tendency for inhibitory control difficulties in children with conduct problems, but it was only marginally significant and was explained by associated symptoms of inattention and hyperactivity. Additionally, it did not provide evidence for response inhibition difficulties in children with CP-PR. The findings are rather unexpected as studies show that children in either condition experience significant difficulties in motor response inhibition tasks regardless of coexisting symptoms of inattention and hyperactivity. The inconsistency in the findings may be explained by the sensitivity of commission errors to detect response inhibition difficulties. CPT commission errors assess the simplest form of response inhibition because they require only that the child delays a prepotent single response (Best & Miller, 2010). The literature indicates that response inhibition impairment in children with conduct problems and reading difficulties is more consistently identified in complex response inhibition tasks where other cognitive functions interfere with performance (Hobson, Scott, & Rubia, 2011; Oosterlaan et al., 1998; Oosterlaan, Scheres, & Sergeant, 2005; Purvis & Tannock, 2000; Raaijmakers et al., 2008; Toupin, Déry, Pauzé, Mercier, & Fortin, 2000; Willcutt et al., 2005). In support to this explanation are findings from studies which, while they found response inhibition deficits in either disorder on complex tasks, failed to find consistent evidence for a difficulty specific to CPT commission errors (de Jong et al., 2009; Hobson et al., 2011; Purvis & Tannock, 2000). Another explanation for the lack of group differences is that response inhibition, as simple as the one assessed by CPT commission errors, is not impaired in samples selected based on non-diagnostic criteria, like the sample of this study. Nonetheless, previous studies of selected samples have not always found an association between conduct problems and reading difficulties and performance in

CPT commission errors (de Jong et al., 2009; Hobson et al., 2011; Purvis & Tannock, 2000). Future research is required to examine response inhibition deficits in children with conduct problems and reading difficulties using tasks of varying complexity and contrasting selected and unselected samples.

Children with CP-PR use less efficient planning strategies because they make more mistakes during TOL task execution. They found it harder to keep with the rules of the task than those in the CP group. They also made more failed attempts, independent of the effect of gender, vocabulary and verbal working memory skills. Rule violations were not a by-product of coexisting reading difficulties but they were explained by differences in intellectual ability. Similarly, increased number of failed attempts was explained by additional problems of inattention and hyperactivity. These findings are in keeping with research showing that the actual source of executive planning difficulties in children with conduct problems is impairment in other areas of functioning, for instance, coexisting attention deficits and hyperactivity (Ogilvie et al., 2011; Oosterlaan et al., 2005), rather than their conduct or reading problems. It also extends previous research by demonstrating that children with CP-PR may be more prone to executive planning deficits than children with CP.

This study shows for the first time that young children, who exhibit conduct problems in the school setting and struggle with reading, have more pronounced executive functioning difficulties than those with conduct problems but normative reading skills. This finding is in agreement with research showing that there is great heterogeneity in the neuropsychological functioning of children with conduct problems (Närhi et al., 2010). It also replicates research on adolescents, which suggest

that the combination of conduct and reading problems is likely to be distinguished by additional neuropsychological complications that do not normally characterize conduct problems free from reading difficulties (Moffitt & Silva, 1988; Poon & Ho, 2014). Their difficulties are partly the result of poor intellectual ability as reflected by low vocabulary and verbal working memory scores, and symptoms of inattention and hyperactivity. The results do not suggest that poor executive function difficulties in children with conduct and poor reading problems are explained by their reading difficulties.

Implications

The findings have two important implications. First, they suggest that coexisting conduct and reading problems are less likely to result from a unique cognitive impairment caused by the interaction of the pure conditions. Despite children in the CP-PR group having poorer performance they were not characterized by a unique pattern of difficulties that would be expected based on the additive combination of the difficulties related to either condition alone. It is worth noting that the CP-PR groups had significantly higher levels of inattention than either group alone. This difference could potentially suggest a unique profile as children with CP-PR appear to be more inattentive. Further research is required to examine whether severity of symptoms of inattention is specifically related to children with CP-PR and why. Additionally, Poon and Ho (2014) found that adolescents with both attention deficit and hyperactivity disorder (ADHD) and reading difficulties performed significantly worse in executive function tasks than those with reading difficulties but without ADHD. These findings suggest that attention deficit and hyperactivity status can cause further heterogeneity

amongst less skilled readers with antisocial behavior. They also allude to a subgroup within the CP-PR population that may suffer specific difficulties of inattention and hyperactivity. This is an important hypothesis that requires replication.

A second implication is that a personalized approach to intervention, where provision is tailored to the child's specific needs, is warranted. Intervention programmes for children with conduct problems need to be differentiated according to whether they have additional reading problems. It is suggested that executive function impairment is included in the intervention protocol for children with conduct and reading problems despite the 'true source' of the impairment not being conduct or reading problems per se (Schoemaker et al., 2012). When planning for provision it is also important to establish the nature of the reading difficulties. A child with a specific reading disorder like dyslexia may not benefit by a programme developed for children whose reading difficulties are the result of limited intellectual opportunities and engagement with reading. A recent systematic review revealed a large number of evidence-based interventions to remediate both word-reading and text comprehension difficulties (Snowling & Hulme, 2011). Finally, in the absence of a unique deficit in children with CP-PR, the findings are in line with explanatory models suggesting that coexisting conduct and reading problems in young children reflect the additive combination of the single conditions. Accordingly, intervention plans should seek to address both areas of need. Literacy intervention programmes have been successfully used to increase reading competence amongst children with conduct problems. Findings from a UK-based randomized controlled trial indicate that the combination of behavioral and literacy parenting intervention focused on training parents how to improve their children's behavior and reading skills, respectively leads to a significantly higher increase in reading performance compared to behavioral

parenting intervention only (Sylva, Scott, Totsika, Ereky-Stevens, & Crook, 2008). A step further in the research to identify effective literacy intervention programmes for children with conduct problems is to test the effectiveness of the candidate programme with children selected for conduct as well as reading problems.

Limitations

The sample size may have not allowed for all significant differences to be detected as the chances for Type II error increase with smaller sample sizes. Nonetheless, because of the trade-off between Type I and Type II error the likelihood that the significant differences found are true is very high. Participants were selected from a school population based on teacher ratings of behavior problems in the school setting. Therefore, the results may not be applicable to clinical populations and to conduct problems exhibited in the home setting. It cannot be determined whether the results are specific to children with word reading or reading comprehension difficulties, because poor performance on the reading test used may be due to either type of reading difficulty. The reading test used is a sentence completion task and relies heavily on good reading comprehension skills, which are considerably dependent on good verbal working memory skills (Sesma, Mahone, Levine, Eason, & Cutting, 2009). As a result, group differences in working memory may have been accentuated by the nature of the test used. Some of the major types of executive function were examined but difficulties in other aspects of executive function cannot be overruled. This study is only a step towards disentangling the relationship between conduct problems and reading difficulties. Further work is required to replicate the reported findings using a larger and more representative sample of ethnic minorities, a tighter definition of conduct problems, which will include parent ratings as well, and a wider range of executive function measures. Additionally, further research is required to

unravel the mechanism whereby inattention and hyperactivity contribute to the reading achievement of children with conduct problems. Finally, an examination of whether children with conduct problems exhibit different behavioral and cognitive deficits as a result of reading disability type is an important extension of this research.

Conclusion

Child conduct problems comprise a heterogeneous condition of psychopathology and a *one size fits all* approach to intervention may not equally benefit all children with conduct problems. The present study shows that children with conduct and reading problems exhibit additional difficulties in executive functioning compared to children with conduct problems but intact reading skills. It is suggested that differential provision should be considered based on whether children with conduct problems have coexisting reading difficulties.

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